



# HOM Transfer Function Measurements and other topics

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ICFA Workshop on High Order Modes in Superconducting Cavities

2014-07-15



# Applicability

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- any linac with photoinjector  
(context is LCLS-II)

# LCLS-II Numbers

## Game of subharmonics

- L-band RF is  $f_0 = 1300$  MHz
- Gun cavity is  $f_0/7 = 185.714$  MHz
- APEX construction uses 1 laser pulse per 5 gun cavity cycles, 37.143 MHz

Most short-pulse lasers have rep-rate between 30 MHz and 100 MHz

99% of the documentation for the planned LCLS-II talks about the photon pulses at the photocathode, and by derivation the electron bunches, being regularly spaced at '1 MHz', sometimes with the footnote that this is really 928.6 kHz.

- One nominal bunch every 40 laser pulses

# What's in a laser?

“A chain of 4 pre-amplifiers gets the seed from the oscillator. After the first two pre-amplifiers, the repetition rate is decreased to 1 MHz by a acousto-optic kicker (AOM), driven by a 2 W 100 MHz pulsed rf signal synchronous with the oscillator. The AOM's rise and fall time are at the 20-30 ns level.”

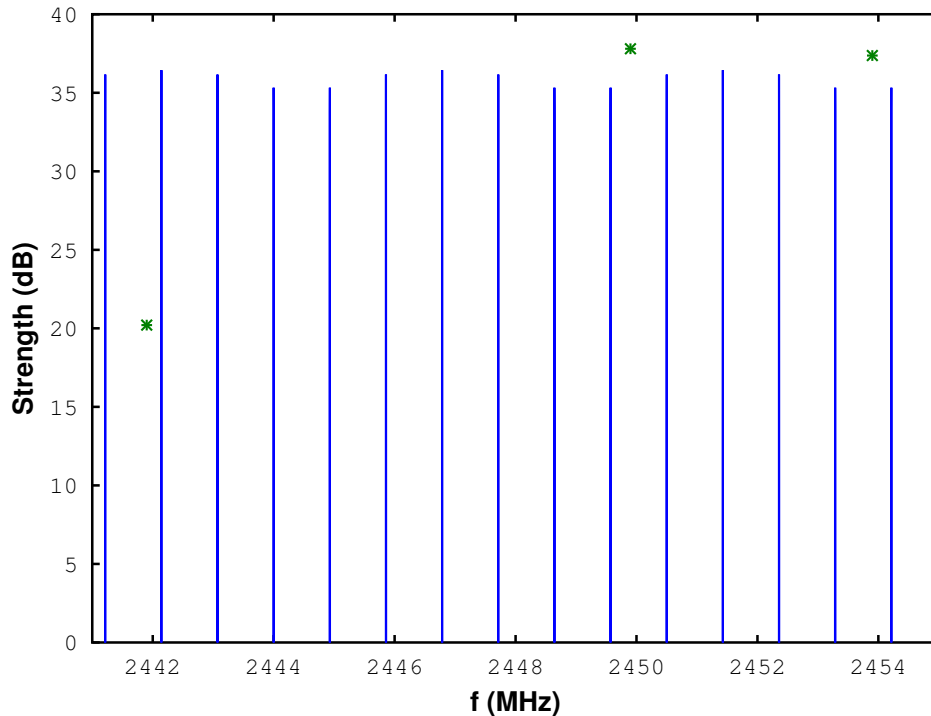
- The Photocathode Laser System for the APEX High Repetition Rate Photoinjector D. Filippetto *et al.*, Proceedings of FEL2013

## Flexible!

There are many limits to how often the AOM can be fired, but especially at low bunch charge, it is pretty much pulse-on-demand subject to the 26.9 ns granularity, and keeping approximately 1 pulse per microsecond or less over tens of microseconds.

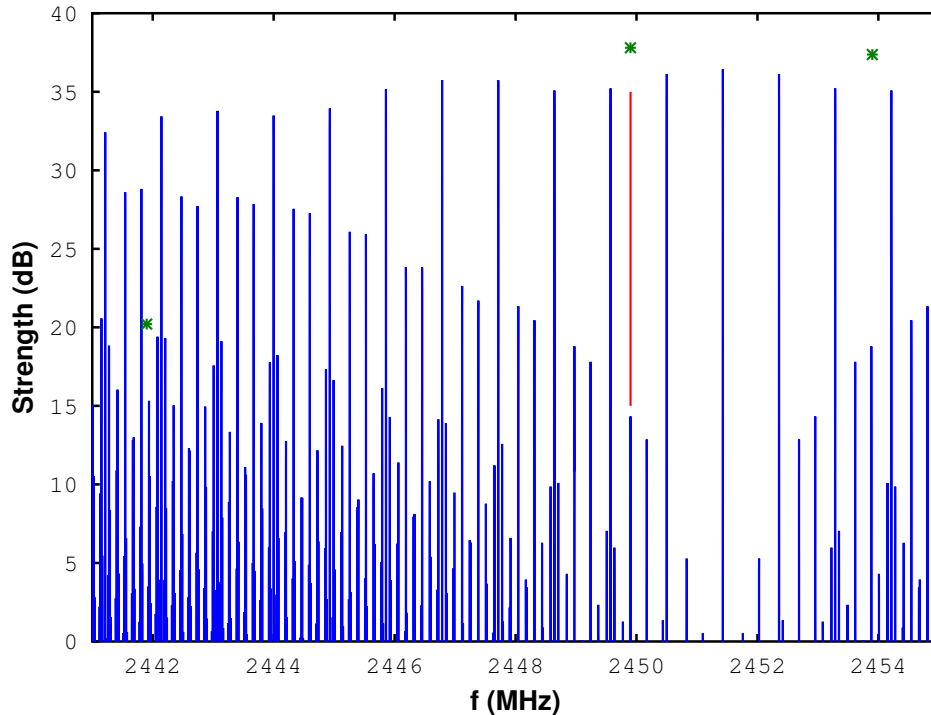
# Normal

Usual spectrum of '1 MHz' beam, with  $TE_{111}$  mode impedances shown.



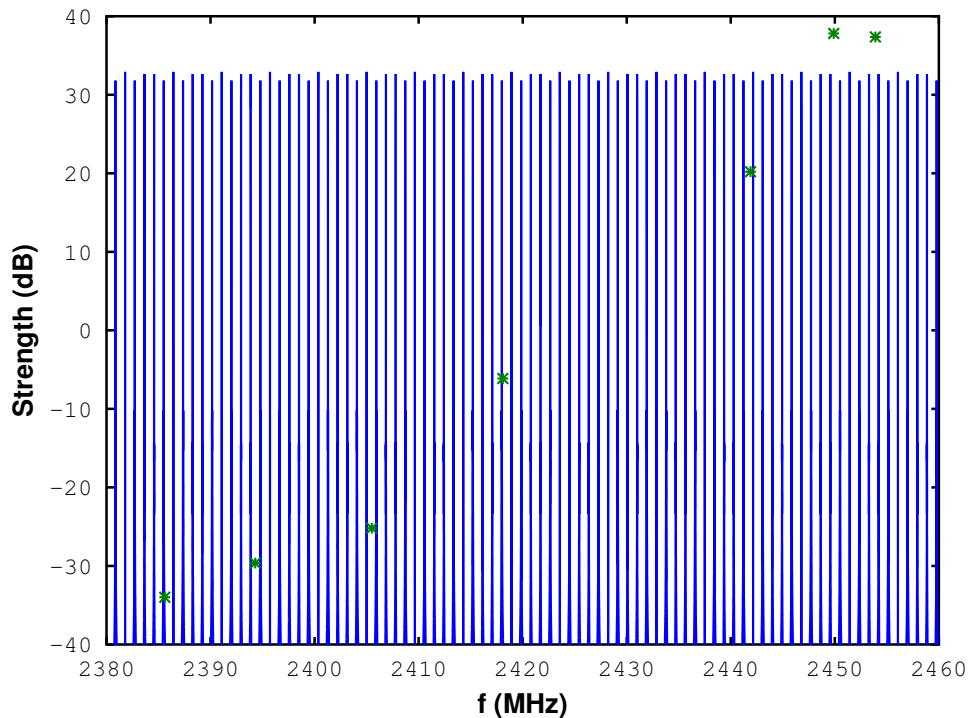
# Abnormal

Same conditions, but jiggle each pulse's timing  $\pm 13$  ns to hit 2449.9 MHz



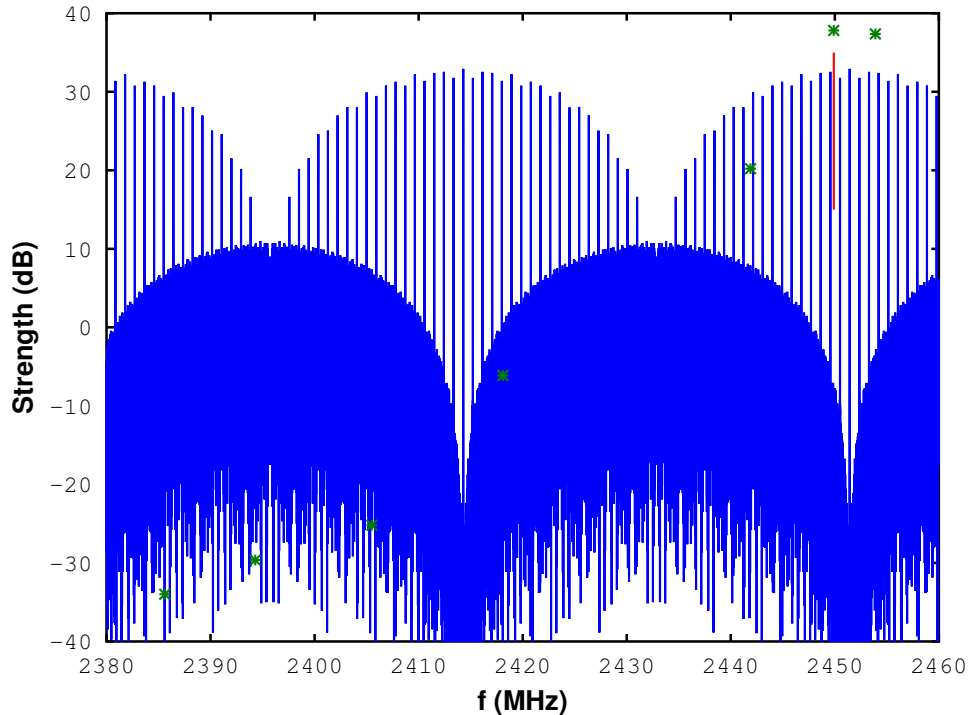
# Normal

Usual spectrum of '1 MHz' beam, with  $TE_{111}$  mode impedances shown.



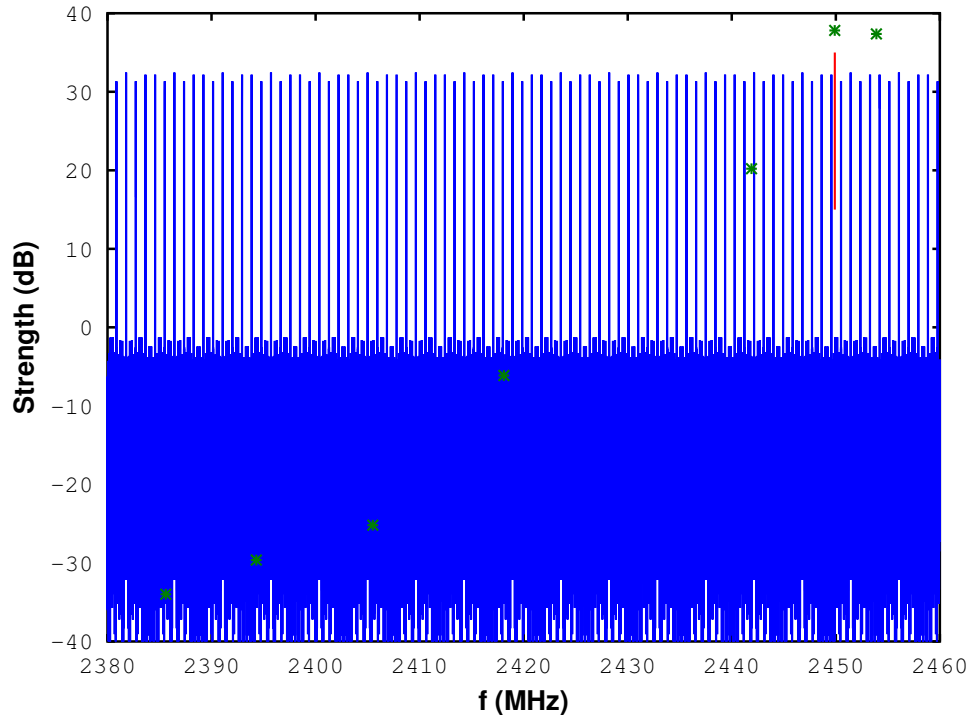
# White phase noise added

Random jitter modulated



# White amplitude noise added

Random 5% pulse dropouts



# Transfer function

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- Excite from photoinjector
- Couple to monopole cavity mode
- Synchronous RF measurement on HOM probe (or fundamental probe)

Timing system planned for LCLS-II is flexible enough to synchronize this stimulus/response over whole accelerator site

# Alternative

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Modulating the bunch charge, as described by Daniel Hall of Cornell, is perhaps simpler to think about. But a full linac's longitudinal bunch propagation is sensitive to bunch charge due to short-range wakes. Nothing in the system besides HOMs (and presumably the end-station photon experiments) is sensitive to  $\pm 13$  ns changes in bunch arrival time.

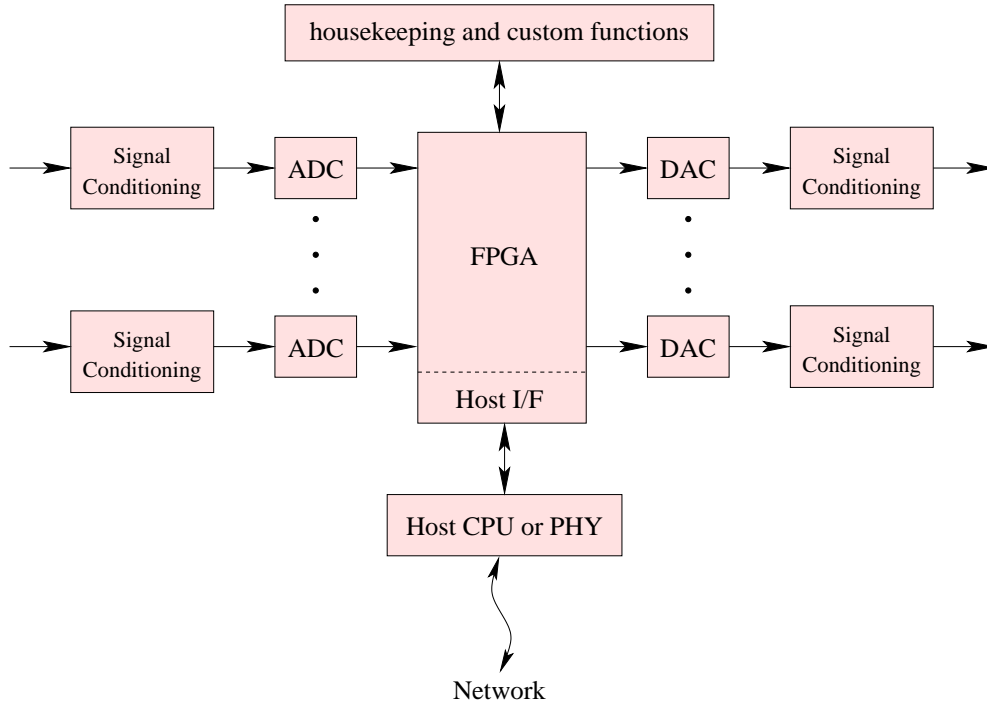
# Conclusions

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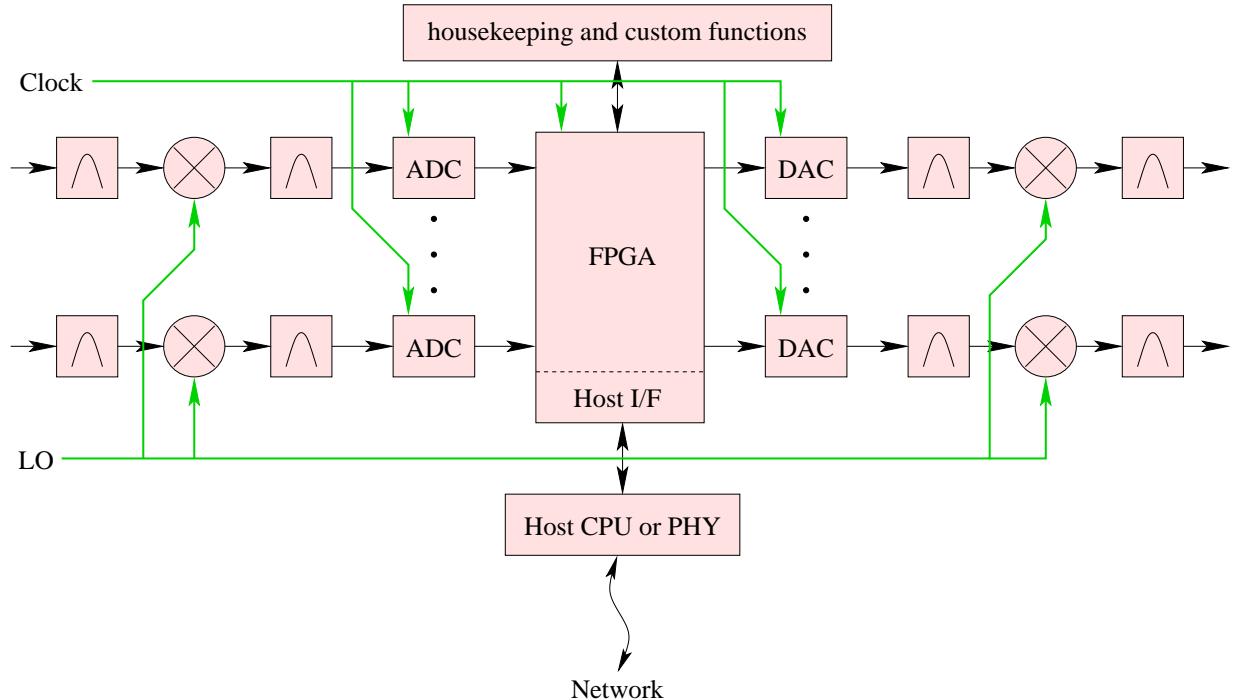
- Photoinjectors don't have to be operated only at their nominal setting
- Pulse-on-demand feature can be used as a programmable frequency source to excite (or avoid exciting) HOMs at any frequency

**Thanks for listening!**

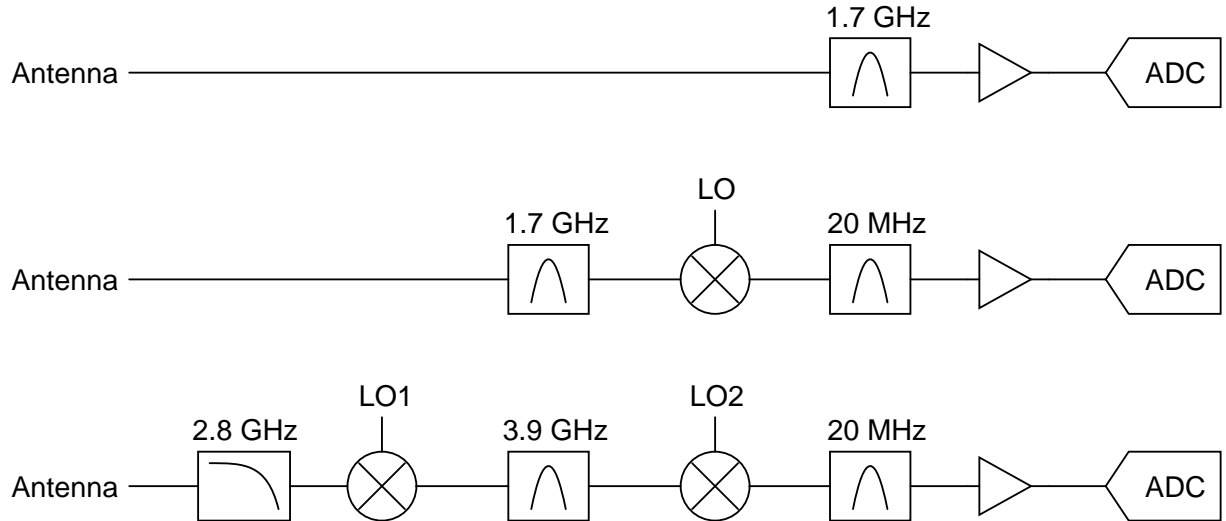
# Familiar Block Diagram



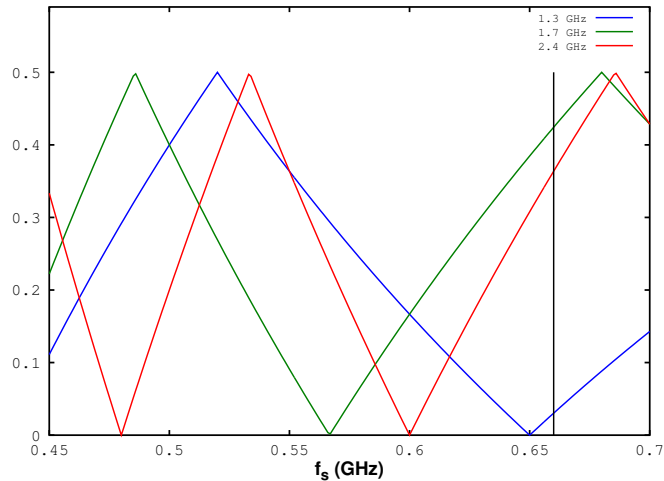
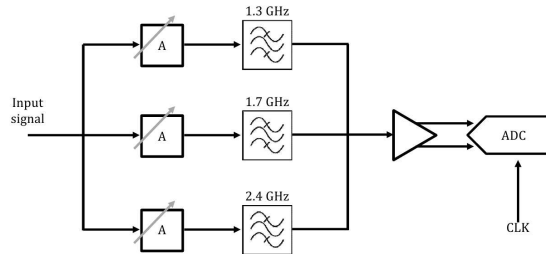
# Familiar Block Diagram



# Data Acquisition



# Data Acquisition - DESY/Bou Habib



# Data Acquisition - LCLS-II LLRF compatible

